

NuTroNS 1:  
Joint EC-IAEA Nuclear Science Training  
Course on Nuclear Science with  
NUCLEONICA, Monaco, 12-15<sup>th</sup> Oct. 2010



# NUCLEONICA: Decay Engine J. MAGILL

European Commission, Joint Research Centre,  
Institute for Transuranium Elements,  
Postfach 2340, 76125 Karlsruhe, Germany



**Some theory...**

**Launching Decay  
Engine...**

**Performing calculation  
with default settings...**

**Exploring calculation  
results...**

**Selecting options...**

**Plotting results...**

## Modern Alchemy: Discovery of transmutation, (Soddy 1901)

In 1901, twenty-four year-old chemist Frederick Soddy and Ernest Rutherford were attempting to identify a mysterious gas that wafted from samples of radioactive thorium oxide. They suspected that this gas—they called it an “emanation”—held a key to the recently discovered phenomenon of radioactivity. Soddy had passed the puzzling gas over a series of powerful chemical reagents, heated white-hot. When no reactions took place, he came to a startling realization. As he told his biographer many years later....

‘I remember quite well standing there transfixed as though stunned by the colossal import of the thing and blurting out- or so it seemed at the time: “Rutherford, this is transmutation: the thorium is disintegrating and transmuting itself into argon gas“. Rutherford’s reply was typically aware of more practical implications, “For Mike’s sake, Soddy, don’t call it *transmutation*. They’ll have our heads off as alchemists“

\*quoted in *Pioneer*, pp 83-84



Frederic Soddy



Joseph Wright (1734-1797)

Simple radioactive decay..

Basic equation first identified by Rutherford

$$dQ/dt = -kQ \quad (1)$$

Q is the number of atoms, k is the decay constant (probability per unit time that a nucleus will decay):

$$k = \ln 2 / \tau$$

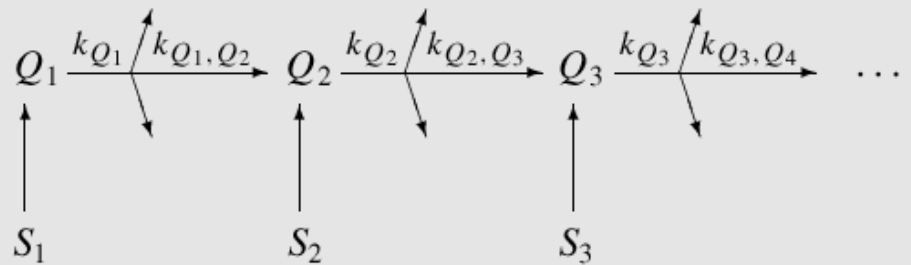
where  $\tau$  is the half-live. Solution of Eq.1...

$$Q(t) = Q(0) e^{-kt} \quad \text{or} \quad Q(t) = Q(0) 2^{-t/\tau}$$

Activity..

$$A(t) = k Q(t)$$

## Successive radioactive decay with branching and source terms



The differential equations governing the above processes:

$$\begin{aligned} \frac{dQ_1}{dt} &= S_1 - k_{Q_1} \cdot Q_1, \\ \frac{dQ_2}{dt} &= S_2 + k_{Q_1, Q_2} \cdot Q_1 - k_{Q_2} \cdot Q_2, \\ \frac{dQ_i}{dt} &= S_i + k_{Q_{i-1}, Q_i} \cdot Q_{i-1} - k_{Q_i} \cdot Q_i, \\ \frac{dQ_n}{dt} &= S_n + k_{Q_{n-1}, Q_n} \cdot Q_{n-1} - k_{Q_n} \cdot Q_i, \end{aligned}$$

*Mr. Bateman, Solution of a system of differential equations, etc. 423*

*The solution of a system of differential equations occurring in the theory of radio-active transformations. By H. BATEMAN, M.A., Trinity College.*

[Read 21 February 1910.]

1. It has been shown by Prof. Rutherford \* that the amounts of the primary substance and the different products in a given quantity of radio-active matter vary according to the system of differential equations,

$$\left. \begin{aligned} \frac{dP}{dt} &= -\lambda_1 P \\ \frac{dQ}{dt} &= \lambda_1 P - \lambda_2 Q \\ \frac{dR}{dt} &= \lambda_2 Q - \lambda_3 R \\ \frac{dS}{dt} &= \lambda_3 R - \lambda_4 T \\ &\dots \dots \dots \end{aligned} \right\} \dots \dots \dots (1).$$

denote the number of atoms of the primary substance and the products which are present at time  $t$ . Prof. Rutherford has worked out the various cases in which the products in addition to the primary substance, but as if the results may be extended to any case without much labour.

The straightforward method is unsymmetrical, and the results of the calculations are needed in which are being carried on in radio-activity. It is worth while to publish a simple and direct method of obtaining the required formulae. Let us denote a set of auxiliary quantities  $p(x)$ ,  $q(x)$ ,  $r(x)$ ,  $s(x)$ ,  $t(x)$ , on a variable  $x$  and connected with the functions  $P(t)$ ,  $Q(t)$ ,  $R(t)$ ,  $S(t)$ ,  $T(t)$  by the equations,

$$p(x) = \int_0^\infty e^{-xt} P(t) dt, \quad q(x) = \int_0^\infty e^{-xt} Q(t) dt, \dots \dots (2).$$

It is easily seen that

$$\begin{aligned} \int_0^\infty e^{-xt} \frac{dP}{dt} dt &= -P(0) + x \int_0^\infty e^{-xt} P(t) dt \dots \dots \dots (3), \\ &= -P_0 + xp, \end{aligned}$$

\* Radio-activity, 2nd edition, p. 582.



H. Bateman

Exact solution:

$$Q_n(t) = \sum_{i=1}^{i=n} \left[ \left( \prod_{j=1}^{j=n-1} k_{j,j+1} \right) \times \sum_{j=i}^{j=n} \left( \frac{Q_i(0) e^{-k_j t}}{\prod_{\substack{p=i \\ p \neq j}}^n (k_p - k_j)} + \frac{S_i (1 - e^{-k_j t})}{k_j \prod_{\substack{p=i \\ p \neq j}}^n (k_p - k_j)} \right) \right]$$

$$Q_n(t) = \prod_{j=1}^{j=n-1} k_{j,j+1} \sum_{j=i}^{j=n} \frac{Q_i(0) e^{-k_j t}}{\prod_{\substack{p=i \\ p \neq j}}^n (k_p - k_j)}$$

First few terms...

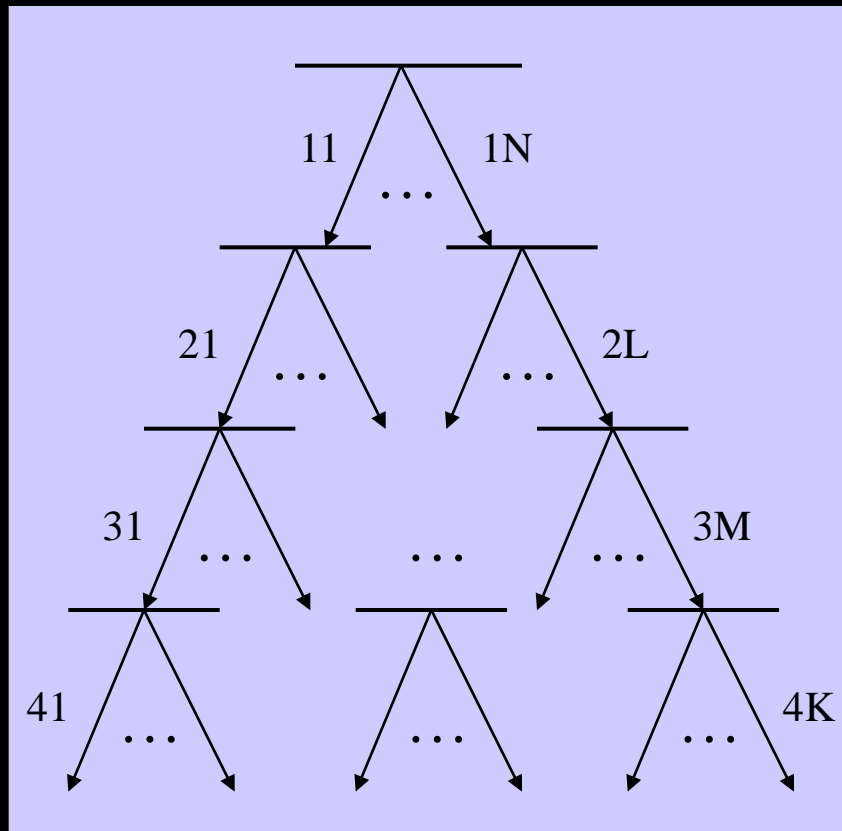
$$Q_1 = Q_1(0) e^{-k_1 t}$$

$$Q_2 = k_{1,2} \left\{ \frac{Q_1(0) e^{-k_1 t}}{k_2 - k_1} + \frac{Q_1(0) e^{-k_2 t}}{k_1 - k_2} \right\}$$

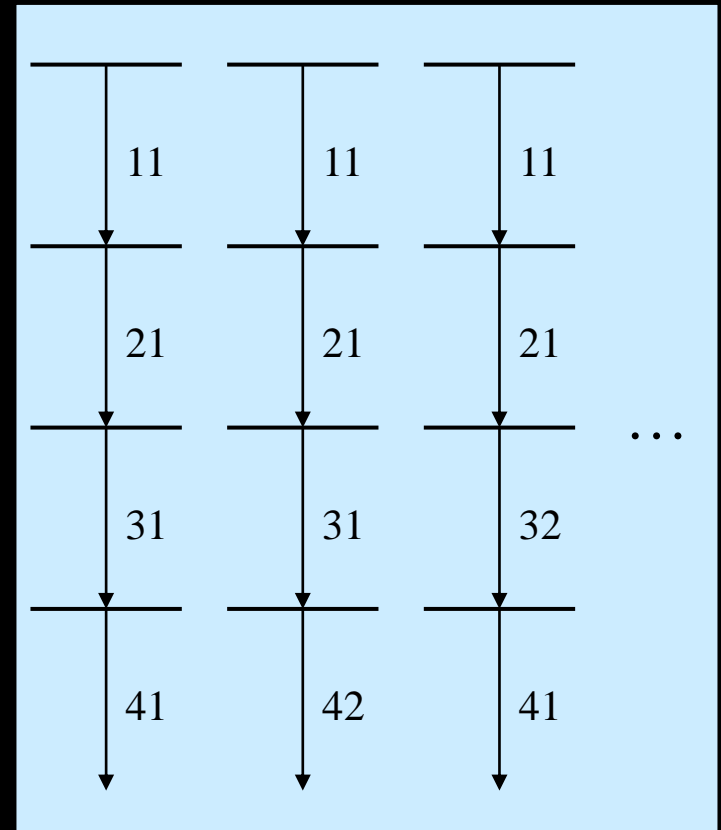
$$Q_3 = k_{1,2} k_{2,3} \left\{ \frac{Q_1(0) e^{-k_1 t}}{(k_2 - k_1)(k_3 - k_1)} + \frac{Q_1(0) e^{-k_2 t}}{(k_1 - k_2)(k_3 - k_2)} + \frac{Q_1(0) e^{-k_3 t}}{(k_1 - k_3)(k_2 - k_3)} \right\}$$



## Decay Tree



## Linear Chains





- Nuclide Explorer
- Mass Activity Calculator
- Decay Engine
- Dosimetry and Shielding**
- Range and Stopping Power
- webKORIGEN
- Universal Nuclide Chart
- Transport and Packaging
- Nuclide Mixtures
- Nucleonica Scripting
- Library Creation
- Extended Graph Module
- Physical Constants
- Nuclide Datasheet
- Radiations
- Fission Yields
- Nuclear Data Retrieval
- Nuclear News
- Conference Calendar

#### Application Centre

- >> Mass Activity Calculator
- >> Decay Engine
- >> **Dosimetry & Shielding**
- >> Range & Stopping Power
- >> webKORIGEN
- >> Universal Nuclide Chart
- >> Transport & Packaging
- >> Nuclide mixtures
- >> Nucleonica Scripting
- >> Library creation for 3rd party software
- >> Radiological Dispersion Module
- >> Extended Graph Module

#### Data Centre

- >> Physical Constants
- >> Nuclide Datasheets
- >> Nuclide Derived Data
- >> Average Cross Sections
- >> Radiations
- >> Prompt Gamma
- >> Fission Yields

#### Knowledge Centre

- >> Nuclear News
- >> Reading room
- >> Useful Weblinks
- >> Ask An Expert
- >> Element Information
- >> Conference Calendar

#### Welcome, Andrey

[Edit Preferences](#)  
[MyCommunity Portal](#)

#### My Last Nuclides

- 92 U235
- 43 Tc90
- 52 Te118
- 34 Se81 m
- 73 Ta155

#### My Nuclide Mixtures

- Transuranics in 1 ton Spent Fuel  
(4.2% enriched, %50GWd/t, 6 years cooling)
- Cs137+Ba137m
- U232+Co60
- Test\_Source\_1

#### My Sources

No sources selected yet

#### My Messages

- Maintenance Work
- Maintenance Work
- Maintenance Work
- NAMLS-9 International Conference on Nuclear Analytical Methods in the Life Sciences
- Request for photos of non-stable elements

>> View

#### User Alerts

**To launch the Decay Engine**

click on Decay Engine in the Application Center list.....

or

choose Decay Engine from the Applications dropdown list....

Logged in as: aberizov Home Search Forum Calculator Disclaimer

nucleonica ... web driven nuclear science

Views Applications My Preferences Help New Alerts

The Nuclide Explorer interface displays a chart of nuclides. The x-axis represents the mass number (A) from 130 to 136, and the y-axis represents the atomic number (Z) from 82 to 86. Nuclides are color-coded by decay mode: alpha (yellow), beta- (cyan), beta+ (pink), IT (white), n (blue), SF (green), p (orange), ec (red), and CE (purple). Stable nuclides are black. The nuclide  $\text{Po}^{218}$  is highlighted with a red box, and a context menu is open over it, with 'Decay Engine' selected.

**Select**

Element: Mass:  $\text{Po}$  218

**Zoom**

View: 5

**Select colour theme:**

Karlsruhe

☒ alpha ☒ beta- ☒ beta+ ☒ IT ☒ n ☒ SF ☒ p ☒ ec ☒ CE

☒ stable

All None

Background

Rn216 45 $\mu\text{s}$	Rn217 540 $\mu\text{s}$	Rn218 35 ms	Rn219 3.96 s	Rn220 55.8 s	Rn221 25 m	Rn222 3.82 d
At215 100 $\mu\text{s}$	At216 300 $\mu\text{s}$	At217 32.3 ms	At218 1.5 s	At219 54 s	At220 3.71 m	At221 2.3 m
Po214 1.6E2 $\mu\text{s}$	Po215 1.78 ms	Po216 150 ms	Po217 1.47 s	Po218 3.1 m	Po219 2 m	Po220 40 s
Bi213 45.59 m	Bi214 19.9 m	Bi215 36.9 s	Bi216 2.17 m	Bi217 1.84 s		
Pb212 10.64 h	Pb213 10.2 m	Pb214 26.8 m	Pb215 36 s			

Ground state: 3127 nuclides from 3127 Metastable: 769 nuclides from 769 Total: 3896 nuclides from 3896

## To launch the Decay Engine

select nuclide of interest in the Nuclide Explorer page.....

then

click right mouse button over it .....

and

choose Decay Engine from the list, which will appear

.....

nucleonica

Applications My Preferences Print

Po218  
3.1 m

Decay Engine  
84 Polonium

Actual Chart: Karlsruhe

Element: Mass:  
Po 218 Nuclide Mixtures Selector

Decay Engine Options

Quantity: Grams 1  
Time: Minutes 3.10E+01

Start Start in background Reset

Quantity: Grams  
Time: Minutes

Start Start in background

Type of graph: Numbers

Version 1.0.0000.0090

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Applications My Preferences Print Help New Alerts

Po218  
3.1 m

Decay Engine  
84 Polonium

Actual Chart: Karlsruhe

Element: Mass:  
Po 218 Nuclide Mixtures Selector

Decay Engine Options

Quantity: Grams 1  
Time: Minutes 3.10E+01

Start Start in background Reset

Parent+Daughters	Half-life	BR
84 Po218	3.1 m	0.99981; 1.90E-08
82 Pb214	26.8 m	1
83 Bi214	19.9 m	0.99979; 2.11E-08
84 Po214	1.6E2 $\mu$ s	1
82 Pb210	22.17 y	1; 1.90E-08
83 Bi210	5.01 d	0.999999; 1.00E-08
84 Po210	1.4E2 d	1
82 Pb206 Stable	stable	
Total:		

84 Po218  
82 Pb214  
83 Bi214  
84 Po214  
82 Pb210  
83 Bi210  
84 Po210  
82 Pb206 Stable  
Total:

Update

Download Excel CSV Separator: Semicolon

Type of graph: Numbers

N (number of atoms)

t [Minutes]

Show Graph Settings  
Print  
Download

Start a calculation using default values....

Element Info in Nucleonica wiki

Nuclide selection tools

Mass-activity calculator

Set the time

Select the value to be plotted on a graph

Set the number of timesteps. To plot a graph up to 40 timesteps can be used

Set the accuracy of the calculation. Default value 1E-2 gives at least the main chain. Min. Zero value gives all chains!

Number of chains with Accuracy Factor > 1E-2

The screenshot displays the Nucleonica web application interface, which is a web-driven nuclear science tool. The interface includes a navigation bar with links for Applications, My Preferences, Print, and Help. A central panel shows a decay chain for Polonium-218 (Po-218) with a half-life of 3.1 minutes. A table of nuclides is visible, showing various isotopes and their half-lives. A sidebar on the left lists elements from Po to Tc. A search bar and a list of nuclides are also present. A red box highlights the 'Decay Engine' section, which includes a 'Polonium Po - NucleonicaWiki' link. Another red box highlights the 'Nuclide Mixtures' section, which lists various mixtures like Cs137+Ba137m, Cs137+Ba137m, Test\_Source\_1, Transuramics in 1 ton Spent Fuel (4.2% enriched, %50GWd/t, 6 years cooling), and U232+Co60. A third red box highlights the 'Mass-activity calculator' section, which includes a 'Back' button and a 'Search' button. A fourth red box highlights the 'Set the time' section, which includes a dropdown menu for time units (Minutes, Nanoseconds, Milliseconds, Microseconds, Seconds, Hours, Days, Week, Month, Years) and a 'Numbers' dropdown menu. A fifth red box highlights the 'Select the value to be plotted on a graph' section, which includes a 'Numbers' dropdown menu. A sixth red box highlights the 'Set the number of timesteps' section, which includes a 'Numbers' dropdown menu. A seventh red box highlights the 'Set the accuracy of the calculation' section, which includes a 'Numbers' dropdown menu. An eighth red box highlights the 'Number of chains with Accuracy Factor > 1E-2' section, which includes a 'Numbers' dropdown menu. The interface also features a search bar, a list of nuclides, and a table of nuclides.

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Views Applications My Preferences Help

New Alerts

86 85 84

86 Rn216 45 µs Rn217 540 µs Rn218 35 ms Rn219 3.96 s Rn220 55.8 s Rn221 25 m Rn222 3.82 d Rn223 24.2 m

85 At215 100 µs At216 300 µs At217 32.3 ms At218 1.5 s At219 54 s At220 3.71 m At221 2.3 m At222 54 s

84 Po214 1.6E2 µs Po215 1.78 ms Po216 150 ms Po217 1.47 s Po218 3.1 m Po219 2 m Po220 40 s

Element: Mass: Po 218

Zoom View: Karlsruhe

Select colour the Karlsruhe alpha

Nuclide Mixtures:

Cs137+Ba137m

Cs137+Ba137m

Test\_Source\_1

Transuramics in 1 ton Spent Fuel (4.2% enriched, %50GWd/t, 6 years cooling)

U232+Co60

Element: Mass: Po 218

Po 198 Po 199 Pr 199 m Pt 200 Pu 201 Ra 201 m Rb 202 Rn 202 Rg 203 Rh 203 Rn 204 Ru 204 Sb 204 Se 204 Sg 204 Si 204 Sm 204 Sn 204 Sr 204 Ta 204 Tb 204 Tc 204

File Edit View Favorites Tools Help

Back

Address http://www.nucleonica.net:81/wiki/index.php/Polonium\_Po

Aberlizov my talk preferences my watchlist my contributions log out

article discussion edit history move watch

nucleonica Polonium Po

Polonium

(Poland, native country of Mme. Curie). Polonium was the first element discovered by Mme. Curie in 1898 while seeking the cause of radioactivity of pitchblend from Joachimsthal, Bohemia. The electroscope showed it separating with bismuth. Polonium is also called Radium F. Polonium is a very rare natural element. Uranium ores contain only about 100 micrograms of the element per ton. Its abundance is only about 0.2% of that of radium. In 1934, it was found that when natural bismuth (<sup>209</sup>Bi) was bombarded by neutrons, <sup>210</sup>Bi, the parent of polonium, was obtained. Milligram amounts of polonium may now be prepared this way, by using the high neutron fluxes of nuclear reactors. Polonium-210 is a low-melting, fairly volatile metal, 50% of which is vaporized in air in 45 hours at 55C. It is an alpha emitter with a half-life of 138.39 days. A milligram emits as many alpha particles as 5 g of radium. The energy released by its decay is so

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nucleonica

Po218  
3.1 m

## Decay Engine 84 Polonium

Actual Chart: Karlsruhe

1  
84 Po218 2.71E+18  
82 Pb214 1.40E+21  
83 Bi214 8.35E+20  
84 Po214 1.15E+14  
82 Pb210 5.25E+20  
83 Bi210 3.28E+14  
84 Po210 2.39E+11  
82 Pb206 Stable 3.21E+06  
Prod = 1.00E+00  
Total = 2.76E+21

2  
84 Po218 2.71E+18  
82 Pb214 1.40E+21  
83 Bi214 8.35E+20  
81 Ti210 1.12E+16  
82 Pb210 9.90E+16  
83 Bi210 5.79E+10  
84 Po210 3.98E+07  
82 Pb206 Stable 4.23E+02  
Prod = 2.10E-04  
Total = 2.24E+21

3  
84 Po218 2.71E+18  
85 At218 4.19E+12  
83 Bi214 2.11E+17  
84 Po214 2.89E+10  
82 Pb210 3.13E+17  
83 Bi210 2.90E+11  
84 Po210 2.76E+08  
82 Pb206 Stable 6.41E+03  
Prod = 1.90E-04  
Total = 3.23E+18

4  
84 Po218 2.71E+18  
82 Pb214 1.40E+21  
83 Bi214 8.35E+20  
82 Pb210 1.57E+16  
83 Bi210 9.85E+09  
84 Po210 7.17E+06  
82 Pb206 Stable 1.17E+02  
Prod = 3.00E-05  
Total = 2.24E+21

5  
84 Po218 2.71E+18  
82 Pb214 1.40E+21  
83 Bi214 8.35E+20  
84 Po214 1.15E+14  
82 Pb210 5.25E+20  
83 Bi210 3.28E+14  
81 Ti206 1.50E+05  
82 Pb206 Stable 1.65E+05  
Prod = 1.32E-06  
Total = 2.76E+21

6  
84 Po218 2.71E+18  
85 At218 4.19E+12  
86 Rn218 9.77E+07  
84 Po214 4.57E+05  
82 Pb210 5.24E+14  
83 Bi210 8.25E+08  
84 Po210 1.08E+06  
82 Pb206 Stable 3.39E+01  
Prod = 1.90E-07  
Total = 2.71E+18

7  
84 Po218 2.71E+18  
85 At218 4.19E+12  
83 Bi214 2.11E+17  
81 Ti210 3.09E+12  
82 Pb210 6.26E+13  
83 Bi210 5.40E+07  
84 Po210 4.82E+04  
82 Pb206 Stable 1.11E+00  
Prod = 3.99E-08  
Total = 2.92E+18

8  
84 Po218 2.71E+18  
82 Pb214 1.40E+21  
83 Bi214 8.35E+20  
84 Po214 1.15E+14  
82 Pb210 5.25E+20  
80 Hg206 3.63E+06  
81 Ti206 1.19E+06  
82 Pb206 Stable 1.42E+06  
Prod = 1.90E-08  
Total = 2.76E+21

9  
84 Po218 2.71E+18  
82 Pb214 1.40E+21  
83 Bi214 8.35E+20  
81 Ti210 1.12E+16  
82 Pb209 6.69E+12  
83 Bi209 2.36E+11  
81 Ti205 Stable 0.00E+00  
Prod = 1.47E-08  
Total = 2.24E+21

10  
84 Po218 2.71E+18  
85 At218 4.19E+12  
83 Bi214 2.11E+17  
82 Pb210 9.39E+12  
83 Bi210 8.71E+06  
84 Po210 8.28E+03  
82 Pb206 Stable 0.00E+00  
Prod = 5.69E-09  
Total = 2.92E+18

Accuracy Factor: 0

Number of timesteps: 10

Number of chains: 23

Reset

Show Details

Create Nuclide Mixture

	Decay	N(atoms)	M(g)	A(Bq)
		2.76E+21	9.78E-01	1.58E+18
	$\beta^-$	1.40E+21	4.97E-01	6.03E+17
99979; 2.10E-04; 3.00E-05	$\beta^-$ ; $\alpha$ ; $\beta^-$ , $\alpha$	8.36E+20	2.97E-01	4.85E+17
	$\alpha$	1.15E+14	4.07E-08	4.85E+17
99981; 1.90E-04	$\alpha$ ; $\beta^-$	2.71E+18	9.81E-04	1.01E+16
99993; 7.00E-05	$\beta^-$ ; $\beta^-$ , n	1.12E+16	3.91E-06	9.97E+13
999; 1.00E-03	$\alpha$ ; $\beta^-$	4.19E+12	1.52E-09	1.94E+12
1.90E-08	$\beta^-$ ; $\alpha$	5.25E+20	1.83E-01	5.20E+11
	$\alpha$	9.77E+07	3.54E-14	1.94E+09
999999; 1.32E-06	$\beta^-$ ; $\alpha$	3.29E+14	1.15E-07	5.26E+08
	$\beta^-$	6.70E+12	2.32E-09	3.96E+08
	$\alpha$	2.39E+11	8.35E-11	1.39E+04
	$\beta^-$	3.64E+06	1.24E-15	5.16E+03
	$\beta^-$	1.34E+06	4.58E-16	3.68E+03
	$\alpha$	2.36E+11	8.21E-11	2.73E-16
		4.80E+06	1.64E-15	0
		0	0	0

Semicolon (";")

☒ Use field qualifier ("")

Click on the column title to arrange the data in ascending/descending order on the parameter chosen

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Applications My Preferences Print Help New Alerts

Po218  
3.1 m

## Decay Engine

### 84 Polonium

Actual Chart: Karlsruhe

Element: Mass:

Po 218 Nuclide Mixtures Selector

Decay Engine Options

#### Decay Engine Settings

<input checked="" type="checkbox"/> Halflives	<input checked="" type="checkbox"/> Masses	<input type="checkbox"/> Gamma Emission Rate	<input type="checkbox"/> Isotopic Power ( $\alpha$ )
<input checked="" type="checkbox"/> Branching Ratio	<input checked="" type="checkbox"/> Activities	<input type="checkbox"/> Spontaneous Fission Rate	<input type="checkbox"/> Isotopic Power ( $\alpha+\beta$ )
<input checked="" type="checkbox"/> Decay Mode	<input type="checkbox"/> Activities (alpha)	<input type="checkbox"/> Ingestion Radiotoxicity	<input type="checkbox"/> Isotopic Power ( $\alpha+\beta+\gamma$ )
<input checked="" type="checkbox"/> Numbers	<input type="checkbox"/> Activities (beta)	<input type="checkbox"/> Inhalation Radiotoxicity	

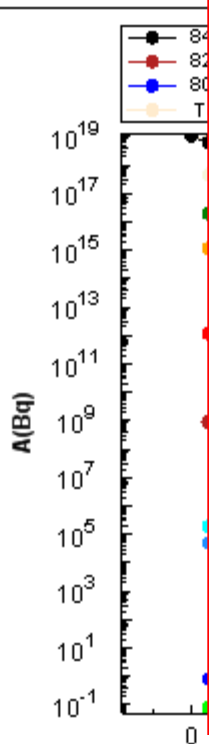
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Radiotoxicity (Sv) = Activity ·  $e(50)$ , where  $e(50)$  - effective dose coefficient, which accounts for radiation and tissue weighting factors, metabolic and biokinetic information.

the heat generated per unit time by the decay radiations (W)

Type of graph: Activities

- ☒ 84 Po218
- ☒ 85 At218
- ☒ 86 Rn218
- ☒ 84 Po214
- ☒ 82 Pb210
- ☒ 83 Bi210
- ☒ 84 Po210
- ☐ 82 Pb206 Stable
- ☒ 81 Tl206
- ☒ 80 Hg206
- ☐ 83 Bi214
- ☒ 81 Tl210
- ☒ 82 Pb209
- ☐ 83 Bi209
- ☐ 81 Tl205 Stable
- ☒ 82 Pb214
- ☒ Total:



### General Graph Settings

Image Width: 500 Image Height: 400

#### Line Style:

Line with Symbols

- ☒ Border
- ☒ Graph Border
- ☒ Show Legend

#### Titles

##### Graph Title:

##### Category (X):

t [Days]

##### Value (Y):

A(Bq)

### Axes

Axis	Type	Min	Max
Y	<input type="radio"/> linear	0.2904	1.03E+19
	<input checked="" type="radio"/> log	<input checked="" type="checkbox"/> Auto scale Y	
X	<input checked="" type="radio"/> linear	0	0.0215
	<input type="radio"/> log	<input checked="" type="checkbox"/> Auto scale X	

### Gridlines and Ticks

#### Category (X) Axis

- ☐ Major Gridlines
- ☐ Minor Gridlines

#### Value (Y) Axis

- ☐ Major Gridlines
- ☐ Minor Gridlines

#### Ticks Location:

- ☐ Outside scale
- ☒ Inside scale
- ☐ Through scale

#### Tick Steps:

- X Axis: Major Step  Minor Step
- ☒ Auto set steps
- Y Axis: Major Step  Minor Step
- ☒ Auto set steps

Redraw Graph

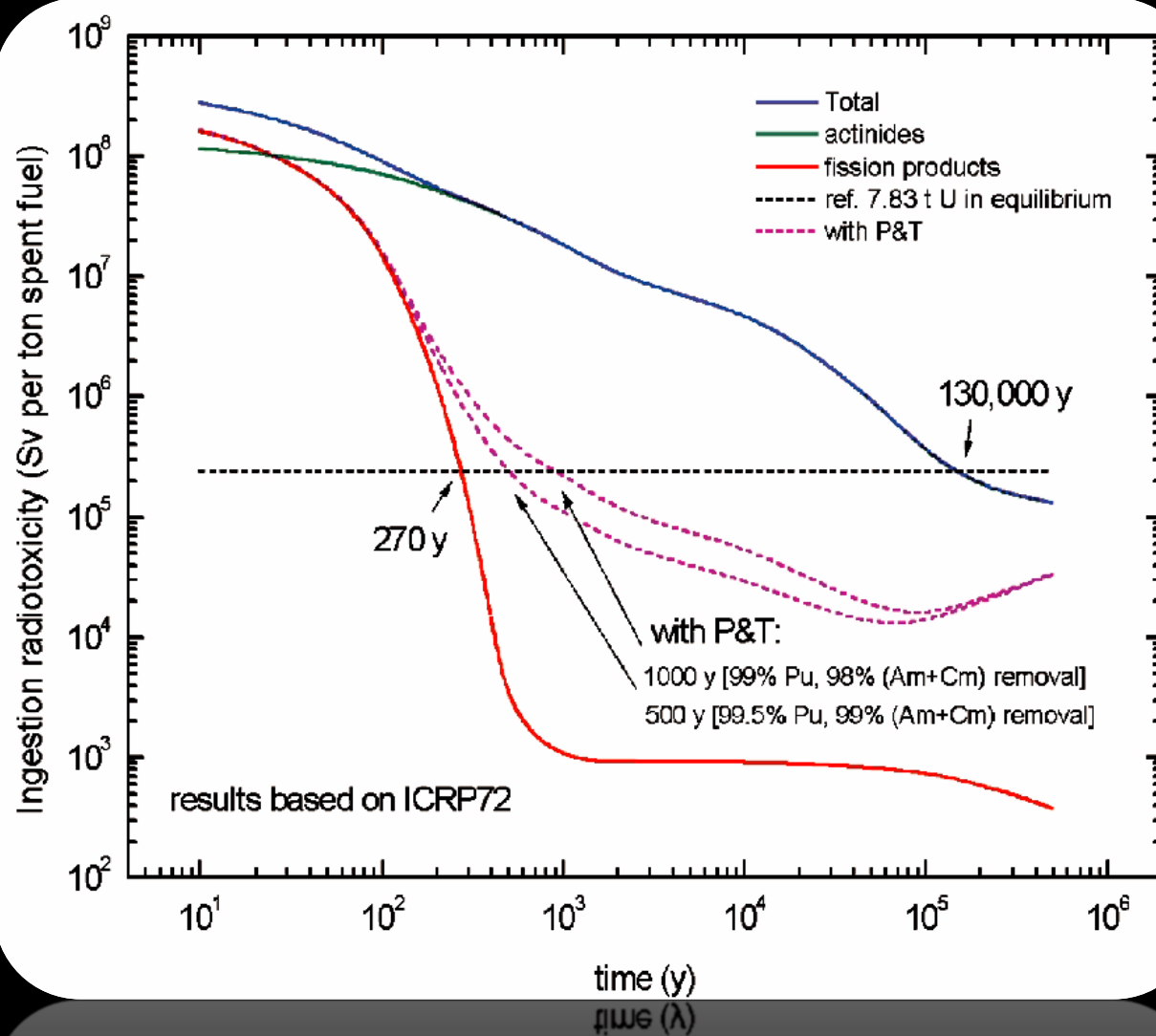
Show Graph Settings

Print

Download

Update





**Some theory...**

**Launching Decay  
Engine...**

**Performing calculation  
with default settings...**

**Exploring calculation  
results...**

**Selecting options...**

**Plotting results...**

Thanks!

